

Taxonomic Review of *Picea alcoquiana* var. *reflexa* (Pinaceae) Based on Cone Morphology

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We reviewed the taxonomic status of *Picea alcoquiana* var. *reflexa* based on the morphology of cones and other characters that had been previously used to distinguish it from var. *alcoquiana*. *Picea alcoquiana* var. *reflexa* has been distinguished from var. *alcoquiana* by its reflexed cone scales. Reflexed cone scales from 831 cones from eight populations and two individual trees covering the entire geographic range of *P. alcoquiana* were categorized into five types. We discovered that cone scale reflection varied among populations and continuously within the species, and therefore could not be used to distinguish var. *reflexa* from var. *alcoquiana*. We concluded that *P. alcoquiana* var. *reflexa* should not be recognized as infraspecifically distinct.

Key words: cone morphology, cone scale reflection, intraspecific variation, *Picea alcoquiana*, *Picea alcoquiana* var. *reflexa*

Picea alcoquiana (Veitch ex Lindl.) Carrière, a tall coniferous tree, is distributed from the northern mountains of Tochigi Prefecture to the southern parts of the Akaishi mountain range (Hayashi 1960, Aizawa 2005; Fig. 1). *Picea alcoquiana* has been treated as comprising three infraspecific taxa; var. *alcoquiana*, var. *reflexa* (Shiras. & Koyama) Fitschen, and var. *acicularis* (Shiras. & Koyama) Fitschen. Recently, Katsuki *et al.* (2004) showed that var. *acicularis*, which was regarded as *P. shirasawae* Hayashi in studies by Hayashi (1960) and Yamazaki (1997), is merely a morphological variant within *P. koyamae* Shiras. *Picea alcoquiana* var. *reflexa* is considered to be endemic to the Akaishi mountain range in central Japan (Hayashi 1960, Farjon 1990). Yamazaki (1995) noted that further investigations on

this variety are necessary to evaluate its status.

Picea alcoquiana var. *reflexa* was discovered by Shirasawa & Koyama (1913) along the Haya-kawa valley in Yamanashi Prefecture and the Ohi valley in Shizuoka Prefecture in the Akaishi mountain range (ca. 1,350–1,650m). *Picea alcoquiana* var. *reflexa* has smaller cones (4.5–7.5 cm) than var. *alcoquiana* (ca. 9 cm; Shirasawa 1911); scales ovoid to broadly ellipsoid, 2.1–2.4 cm long, 1.5–2.0 cm wide, and nearly entire on the upper margin, apically narrowed, basally reflexed, particularly near the base of the cone, and with a smooth surface without lengthwise striations; wings of the seeds shorter and wider and covering the upper part of the seeds as in *Larix kaempferi*. Farjon (1990) distinguished *P. alcoquiana* var. *reflexa* from var. *alcoquiana* on the

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TABLE 1. Localities, number, and size of cones collected and measured in each population or tree.

Locality	Abbr.	Lat. (N)	Long. (E)	Alt. (m)	N	Length (cm) [§]	Width (cm) [§]
<i>Collected from populations</i>							
1. Mt. Hirugatake, Tochigi Pref.	HRU	37.02	139.47	1,550-1,820	48	5.8±0.9	2.5±0.3
2. Mt. Takahara, Tochigi Pref.	TKA	36.54	139.46	1,630-1,780	31	6.3±0.8	2.4±0.2
3. Kirigamine, Nagano Pref.	KGM	36.10	138.08	1,660-1,840	37	7.6±1.5	2.6±0.2
4. Kiyosato, Yamanashi Pref.	KYS	35.56	138.25	1,360-1,460	164	8.9±1.1	2.7±0.3
5. Karisaka-Pass, Yamanashi Pref.	KSK	35.53	138.47	1,600-2,070	95	7.7±0.8	2.7±0.2
6. Mt. Toyoguchi, Nagano Pref.	TYO	35.33	138.07	1,800	24	8.7±1.1	2.8±0.2
7. Mt. Mitsutoge, Yamanashi Pref.	MIT	35.33	138.49	1,600-1,760	87	9.0±0.9	2.6±0.2
8. Mt. Fuji, Shizuoka Pref.	FUJ	35.22	138.41	1,470-1,620	221	8.4±1.5	2.7±0.2
Total					707	8.2±1.5	2.6±0.2
<i>Collected from a single tree</i>							
9. Mt. Fuji, Shizuoka Pref.	FUJ2	35.22	138.41	1,500	100	7.8±0.9	3.2±0.3
10. Kurokouchi, Nagano Pref.	KUR	35.52	138.11	1,910	24	8.9±0.5	2.6±0.1

[§] Length and width of water-immersed cones are expressed as mean ± SD.

basis of more pubescent young shoots, shorter needles and smaller cones with entire, apically narrowed, reflexed scales. Yamazaki (1995) mentioned only the reflection of the scales as being distinctive of this variety. Sugimoto (1987) adopted the name *P. bicolor* (Maxim.) Mayr forma *reflexa* (Shiras. & Koyama) Satake for this variety. Baba (1997), in the Flora of Nagano Prefecture, recognized *P. alcoquiana* forma *reflexa*. If only the reflexed scales were to be used as a distinctive characteristic, the distribution of var. *reflexa* would be more widespread and not restricted to just the Akaishi mountain range. It would be prevalent in regions such as Mt. Yatsugatake, the Chichibu mountain range, and Mt. Fuji in Yamanashi Prefecture (The Assoc. for the Flora of Yamanashi Pref. 1982).

The morphological characteristics of the cones are important in classifying the species of *Picea* (Schmidt 1989, Farjon 1990). Konishi & Suzuki (1997) studied variation in the cone morphology of *P. glehnii* (F. Schmidt) Mast., which is widely distributed in Hokkaido and locally in southern Sakhalin and northern Honshu. They found large variation in cone morphology among the individuals in each population. *Picea alcoquiana* may also

show variation in cone morphology and var. *reflexa* might only be a morphological variant within the species.

In this study, we examined the cone scale characteristics of *Picea alcoquiana* var. *reflexa* by using previous descriptions and specimens, including the type specimen of var. *reflexa*. Our goal was to clarify the variation in cone morphology in *P. alcoquiana* and to assess the taxonomic status of var. *reflexa* from our findings.

Materials and Methods

Shirasawa & Koyama (1913) did not designate a type specimen of *Picea alcoquiana* var. *reflexa*. We discovered two specimens at TI and TFA, which were collected by M. Koyama in October 1911 along the Hayakawa valley in Yamanashi Prefecture and on Mt. Igawa along the Ohi valley in Shizuoka Prefecture. Based on the collector, date of collection, place of collection and the description in Shirasawa & Koyama (1913), we determined that these specimens must be the original material of *P. alcoquiana* var. *reflexa*. We were unable to find other specimens that could be considered original material at

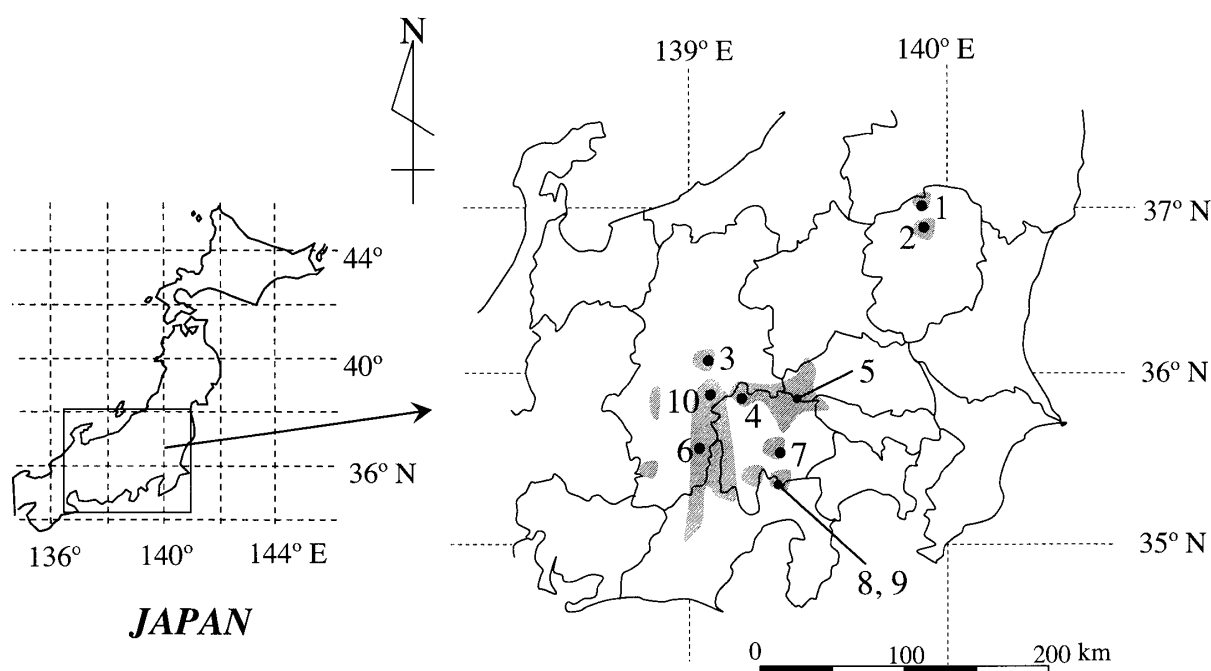


FIG. 1. Geographic distribution of *Picea alcoquiana* in Japan (hatched area) based on Hayashi (1960) and Aizawa (2005) and sampling locations of cone materials (dots). Locality numbers correspond to Table 1. The hatched area including localities No. 6 and 10 is the Akaishi mountain range. Each compartment in figure on right indicates a prefecture; prefectures are listed in Table 1.

KYO, MAK, TNS, and TUS. The specimen at TI consisted of a fertile branch with two cones while the other at TFA consisted of only nine cones. We therefore designated the more complete specimen at TI as the lectotype. We also examined other specimens of *P. alcoquiana* in TFA, TI, TOFO, and TUS.

To clarify the intraspecific variation in the cone morphology of *Picea alcoquiana*, we sampled cones from March to July in 2004 in eight populations, covering the entire geographic range of *P. alcoquiana* from the northernmost locality, Mt. Hirugatake, to the Akaishi mountain range (Fig. 1, Table 1). Fallen cones were collected from the forest floor. It was not possible to identify individual trees from which the cones had fallen, except at Kurokouchi in the Akaishi mountain range in Nagano Prefecture and on Mt. Fuji in Shizuoka Prefecture, where collection of cones from specific trees was possible. After sampling, the cones were completely dried to cause the scales to open. The degree of reflection of the scales at the basal half of

the cones was assessed using 831 cones from eight populations and two individual trees. The degree of reflection was categorized into five grades (Fig. 2): 0, not reflexed; I, slightly reflexed; II, reflexed; III, strongly reflexed; and IV, rolled. Since the illustration in Shirasawa & Koyama (1913) showed that the scales of var. *reflexa* were reflexed even when the cones were closed, we noted whether the scales were reflexed after the cones were closed by immersing them in water for one day. Results from 4–10 cones with various degrees of scale reflection in each population showed that the scales remain reflexed after immersion, although reflection was slightly reduced in most of the cones (Fig. 2). Using an electron caliper square, we also measured the length and width of 24–221 water-immersed cones from each population or tree.

Results and Discussion

The distinctive characteristics of *Picea alcoquiana* var. *reflexa* appear to have been based on the obser-

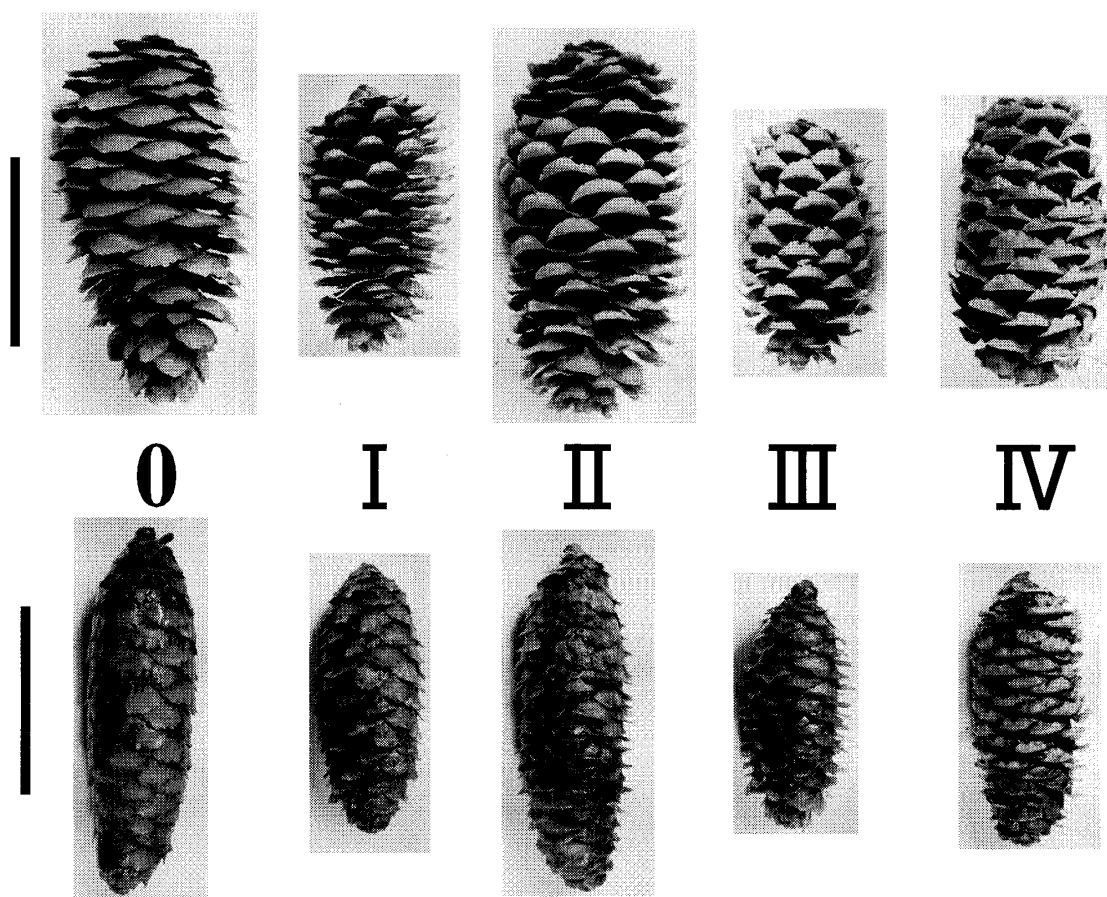


FIG. 2. Degree of scale reflection in basal half of cone. Five categories of reflection are used for dried cones (the upper row). Lower row shows water-immersed cones. Cones in categories 0 and II were collected on Mt. Fuji; I, Mt. Takahara; III, Mt. Hirugatake; IV, a single tree on Mt. Fuji. Scale bars = 5 cm.

vation of a limited number of specimens. The type specimen of var. *reflexa* at TI had young shoots with short, pale yellow hairs (Fig. 3a). Farjon (1990) regarded pubescence on young shoots as a distinctive characteristic of var. *reflexa*. Consistent with descriptions in Hayashi (1960), the leading shoots of tall, mature trees and cone-bearing shoots of var. *alcoquiana* were covered with dense, short, soft hairs (Kimura s. n. [TUS-29843], Aizawa 02-244 [TOFO]). Farjon (1990) regarded the short needles as distinctive of var. *reflexa*, but our observations indicated that the needles on leading, bough, and cone-bearing shoots tended to be shorter and thicker than those on other shoots. Shirasawa & Koyama (1913) regarded shorter and wider seed wings covering the upper side of the seed as a distinctive

characteristic. We found, however, that the seed wing covered only a small part of the upper side of the seed on the type specimen (Fig. 3b) and in our population samples. Although the scale margins of the type specimen were reported to be entire, they are actually finely serrate (Fig. 3c) similar to those of other specimens and to our samples. Excluding cone scale reflection, the characteristics that were previously regarded as distinctive cannot be used to distinguish between vars. *reflexa* and *alcoquiana*.

The mean cone length and width for all the populations we examined was 8.2 ± 1.5 (range 4.0-11.8) cm and 2.6 ± 0.2 (range 1.8-3.6) cm, respectively (Table 1). The cone length of var. *reflexa* was reported to be 4.5-7.5 cm (Shirasawa & Koyama 1913), which is within the range of *Picea*

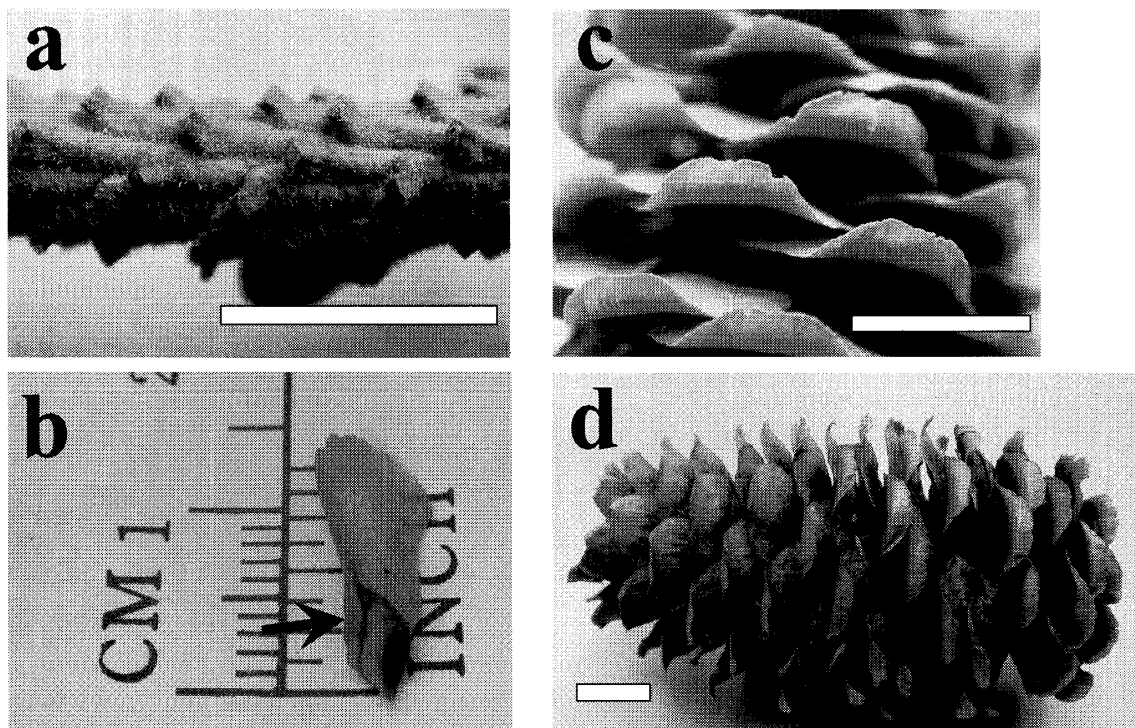


FIG. 3. Photographs of parts of type specimen of *Picea alcoquiana* var. *reflexa*—Mt. Igawa, Shizuoka Pref., Japan, Oct. 11, 1911, *M. Koyama* s.n. (lectotype, TI). a: Young shoot with pubescence, b: Seed wing covers small part of upper part of seed (arrow), c: Finely serrate scale margins, d: Cone with reflexed scales. Scale bars = 1 cm.

alcoquiana. Variety *reflexa* therefore cannot be distinguished in *P. alcoquiana* on the basis of cone size. Our observations confirmed the strong reflection of the scales in the basal half of the cone on the type specimen (Fig. 3d). However, the cone scales showed various degrees of reflection in populations from the entire range of distribution of *P. alcoquiana*, and cone scale reflection varied continuously within the species (Fig. 4). Thus, cone scale reflection did not satisfactorily distinguish var. *reflexa* in *P. alcoquiana*.

Variation within individuals was less pronounced than that within the species. We did not detect cones with reflexed scales from the tree in Kurokouchi (Fig. 4). On Mt. Mitsutoge, we noted that none of the cones that remained in the crown of a newly fallen tree had reflexed scales (*Aizawa* 02-244 [TOFO]). In contrast, all the cones that were collected from the tree on Mt. Fuji had grade IV scales, *i.e.*, rolled scales (Fig. 2, 4). In Kiyosato, all

the cones with reflexed scales above grade II were probably derived from a single tree (Fig. 4). These observations imply that variation in cone scale reflection within individuals is consistent, similar to the cone morphology of *Picea glehnii* studied by Konishi and Suzuki (1997).

Thus, none of the morphological characteristics previously proposed satisfactorily distinguish between *Picea alcoquiana* vars. *reflexa* and *alcoquiana*; var. *reflexa* should not be regarded as an intraspecific taxon of *P. alcoquiana*.

Taxonomic Treatment

Picea alcoquiana (Veitch ex Lindl.) Carrière in *Traité Gén. Conif.*, ed. 2, 1: 343 (1867). “alcockiana.” see Note.

Abies alcoquiana Veitch ex Lindl. in *Gard. Chron.* 1861: 23 (1861).

Picea japonica Regel in *Index. Seminum Hort.*

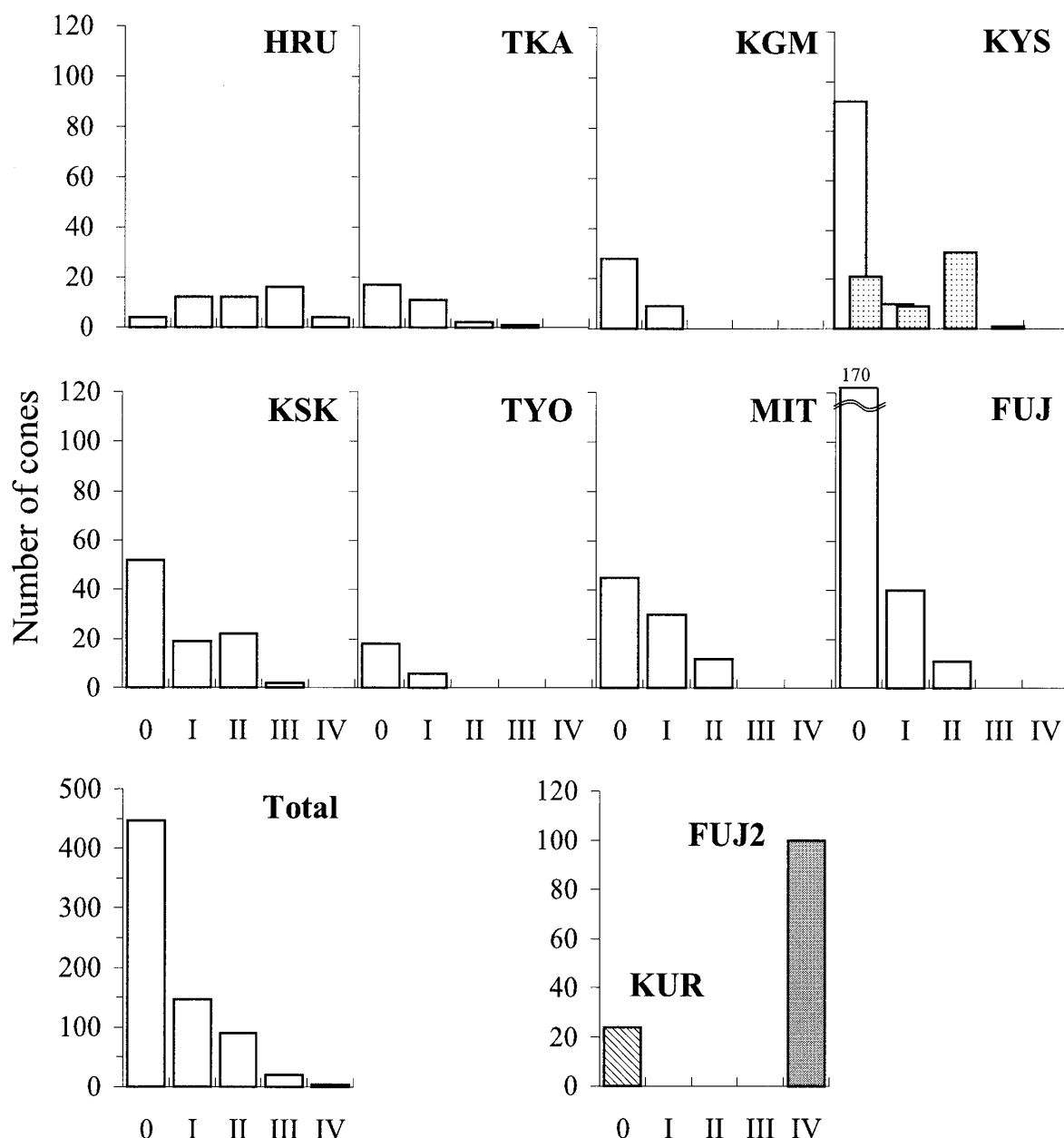


FIG. 4. Frequency distribution of degree of scale reflection in each population or tree. Abbreviations are shown in Table 1. Cones collected from a single tree in Kurokouchi (▨) and on Mt. Fuji (▩), and around a single tree in Kiyosato (▤).

Petrop. 1865: 33 (1865). (name only). nom. nud.

Abies bicolor Maxim. in Bull. Acad. Imp. Sci. Saint-Petersbourg 10: 488 (1866). Type: Japonia [JAPAN], Yokohama, Fudzi-yama [Mt. Fuji], Nov. 3/15 [from 3rd to 15th?], 1862, *Maximowicz s. n.* (lectotype: LE [designated by Orlova L. in Grubov 2004], not seen, isolectotypes [not isotypes]: GH, L, NY, and US, digital images!, syntypes: LE [Japonia, Nippon, prov. Senano, 1864, *Tschonoski s.n.*, not

seen]).

Pinus alcoquiana (Veitch ex Lindl.) Parl. in DC., Prodr. 16(2): 417 (1868).

Pinus bicolor (Maxim.) Parl. in DC., Prodr. 16(2): 418 (1868). (name only as a synonym of *Pinus alcoquiana*). nom. nud.

Picea bicolor (Maxim.) Mayr in Monogr. Abietin. Japan. Reich.: 49, t.3 8 (1890).

Picea bicolor (Maxim.) Mayr var. *reflexa*

Shiras. & Koyama in Bot. Mag. Tokyo 27: 129, t.2 9-17 (1913). Type: Sun-shu Province [JAPAN, Shizuoka Prefecture], Igawa-yama [Mt. Igawa], Oct. 11, 1911, *M. Koyama s. n.* (lectotype: T!!, **designated here**, syntype: TFA! [Hayakawa, Oct. 1911, *M. Koyama s. n.*]).

Picea alcoquiana (Veitch ex Lindl.) Carrière. var. *reflexa* (Shiras. & Koyama) Fitch in Beissner, Handb. Nadelholzk. ed.3: 25 (1930).

Picea bicolor (Maxim.) Mayr f. *reflexa* (Shiras. & Koyama) Satake in Sugim., Conif. World: 28 (1987). (name only). nom. nud.

Picea alcoquiana (Veitch ex Lindl.) Carrière. f. *reflexa* (Shiras. & Koyama) Baba in T. Shimizu, Fl. Nagano Pref.:274 (1997). (name only). nom. nud.

Note: A lectotype has not been designated for *Abies alcoquiana*, the basionym of *Picea alcoquiana* (Greuter & Pitt 1993, Farjon pers. comm.). A specimen in K ("Collection of Dr. M. T. Masters," K-0002523, digital image!) has the annotations: "type specimen from herb. Veitch, Jan. 1880, Fertile branch with two cones, Fusi yama, 6,000-7,000 [feet]," "Alcockiana type! description." Although the name of the collector is lacking, the specimen must have been collected by J. G. Veitch in September 1860 (cf. Murray 1863). Although this specimen may qualify as type material, the digital image of it showed that it consists of only a few cone scales and seeds. Farjon (pers. comm.) suggested the necessity of designating a neotype.

Specimens examined: Honshu. **Tochigi Pref.:** Kuroiso-city and Nasu-gun Shiobara-town, Mt. Hirugatake. *M. Aizawa s. n.* Mar. 20, 2004 (TOFO); Shioya-gun, Fujihara-town, Mt. Takahara. *M. Aizawa & K. Matsunaga s. n.* Jul. 1, 2004 (TOFO); **Nagano Pref.:** Mt. Hachibuse. *C. Kimura*, Aug. 26, 1967 (TUS-29843); Suwa-gun, Mt. Kamanashi, Dogasawa, alt. 1,700m. *T. Yamazaki s. n.* Jun. 14, 1968 (TI); Kamiina-gun, Miwa-village, Ogurogawa-oku. *s. n.*, Jun. 28, 1949 (TFA); Shimoina-gun, Kami-village. *s. n.* Oct. 30, 1950 [cones with rolled scales] (TFA); **Yamanashi Pref.:** Mt. Kushigata. *H. Uematsu s. n.* Oct. 1980 (TFA); Higashi-

yamanashi-gun, Mitomi-village, Karisaka-pass. *M. Aizawa & T. Katsuki s. n.* Apr. 28, 2004 (TOFO); Hokuto-city, Kiyosato, Ryusen-kyo. *M. Aizawa s. n.* May 22, 2004 (TOFO); Minamitsuru-gun, Nishikatsura-town, Mt. Mitsutoge. *M. Aizawa s. n.* Apr. 11, 2004 (TOFO); Minamitsuru-gun, Kawaguchiko-town, Mt. Mitsutoge. *M. Aizawa* 02-244, Oct. 31, 2002 [leading and cone-bearing shoots with dense short, soft hairs] (TOFO); Saitama Pref.: Chichibu-gun, Otaki-village, Mt. Oh. *M. Aizawa s. n.* Apr. 27, 2005 [cones with rolled scales] (TOFO); **Shizuoka Pref.:** Misakubo-town, Mt. Tochu. *s. n.* [cones with rolled scales] (TFA); Misakubo-town, Shirokura. *Y. Kobayashi s. n.* (TFA); Fujinomiya-city, Mt. Fuji, Osawa-kuzure. *M. Aizawa & E. Maruta s. n.* Jul. 12, 2004 (TOFO), Fujinomiya-city, Mt. Fuji, Osawa-kuzure. *M. Aizawa & E. Maruta s. n.* Jul. 12, 2004 [cones with rolled scales] (TOFO).

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